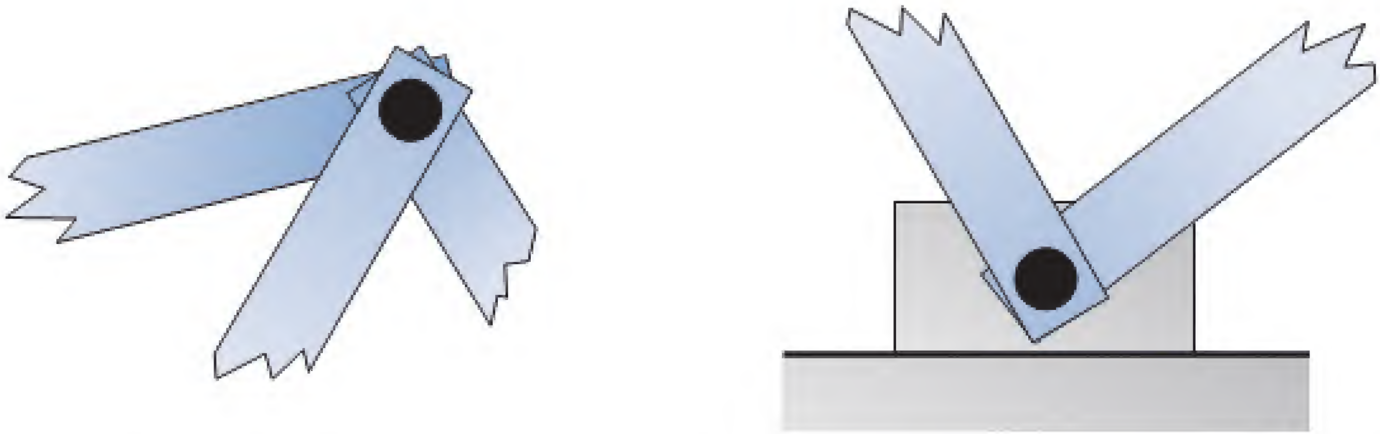


(a) Three rotating links

(b) Two rotating and one sliding link

Figure 1.29 shows a mechanical press used to exert large forces to insert a small part into a larger one. Draw a kinematic diagram, using the end of the handle as a point of interest. Also compute the degrees of freedom.

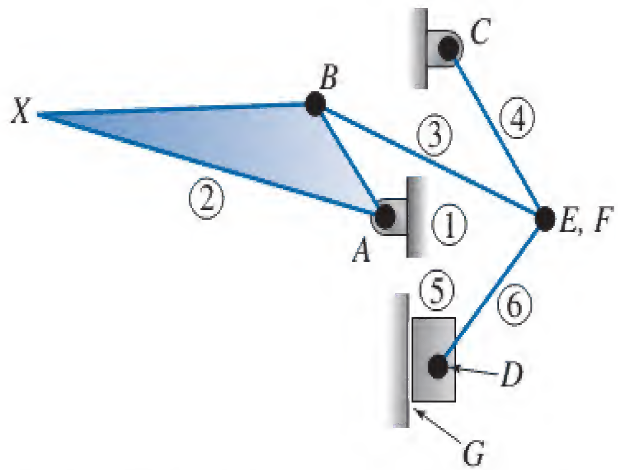


FIGURE 1.30 Kinematic diagram for Example Problem 1.8.

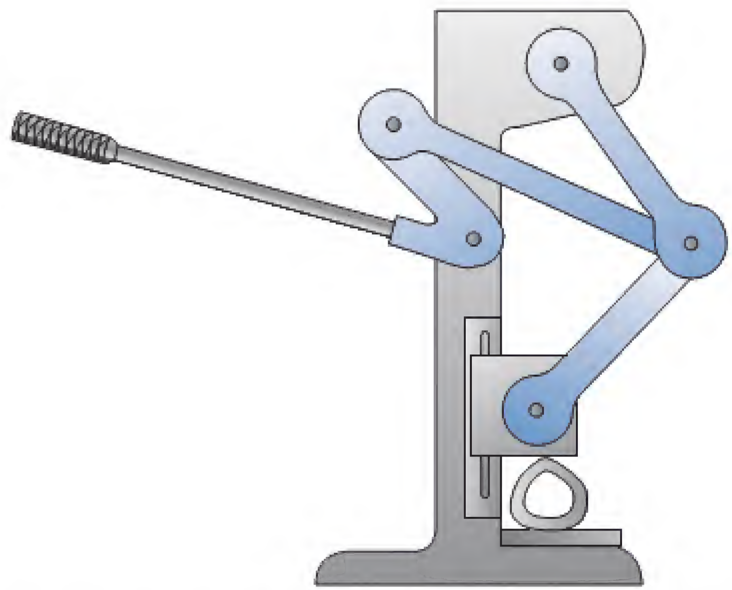


FIGURE 1.29 Mechanical press for Example Problem 1.8.

Calculate Mobility

To calculate the mobility, it was determined that there are six links in this mechanism, as well as six pin joints and one slider joint. Therefore,

$$n = 6, j_p = (6 \text{ pins} + 1 \text{ slider}) = 7, j_h = 0$$

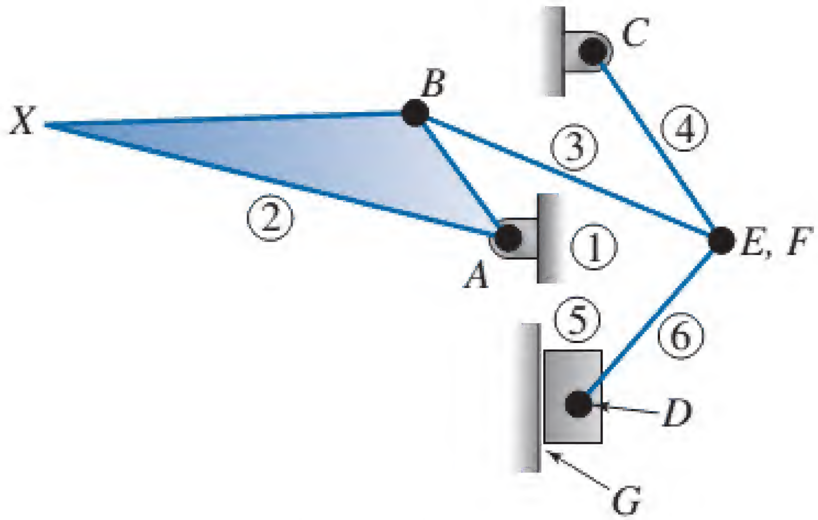


FIGURE 1.30 Kinematic diagram for Example Problem 1.8.

$$M = 3(n - 1) - 2j_p - j_h = 3(6 - 1) - 2(7) - 0 = 15 - 14 = 1$$

With one degree of freedom, the mechanical press mechanism is constrained. Moving only one link, the handle, precisely positions all other links in the press, sliding the press head onto the work piece.

1.10.1 Grashof's Criterion

s = length of the shortest link

l = length of the longest link

p = length of one of the intermediate length links

q = length of the other intermediate length links

Grashof's theorem states that a four-bar mechanism has at least one revolving link if:

$$s + l \leq p + q$$

Conversely, the three nonfixed links will merely rock if:

$$s + l > p + q$$

All four-bar mechanisms fall into one of the five categories listed in Table 1.2.

TABLE 1.2 Categories of Four-Bar Mechanisms

Case	Criteria	Shortest Link	Category
1	$s + l < p + q$	Frame	Double crank
2	$s + l < p + q$	Side	Crank-rocker
3	$s + l < p + q$	Coupler	Double rocker
4	$s + l = p + q$	Any	Change point
5	$s + l > p + q$	Any	Triple rocker

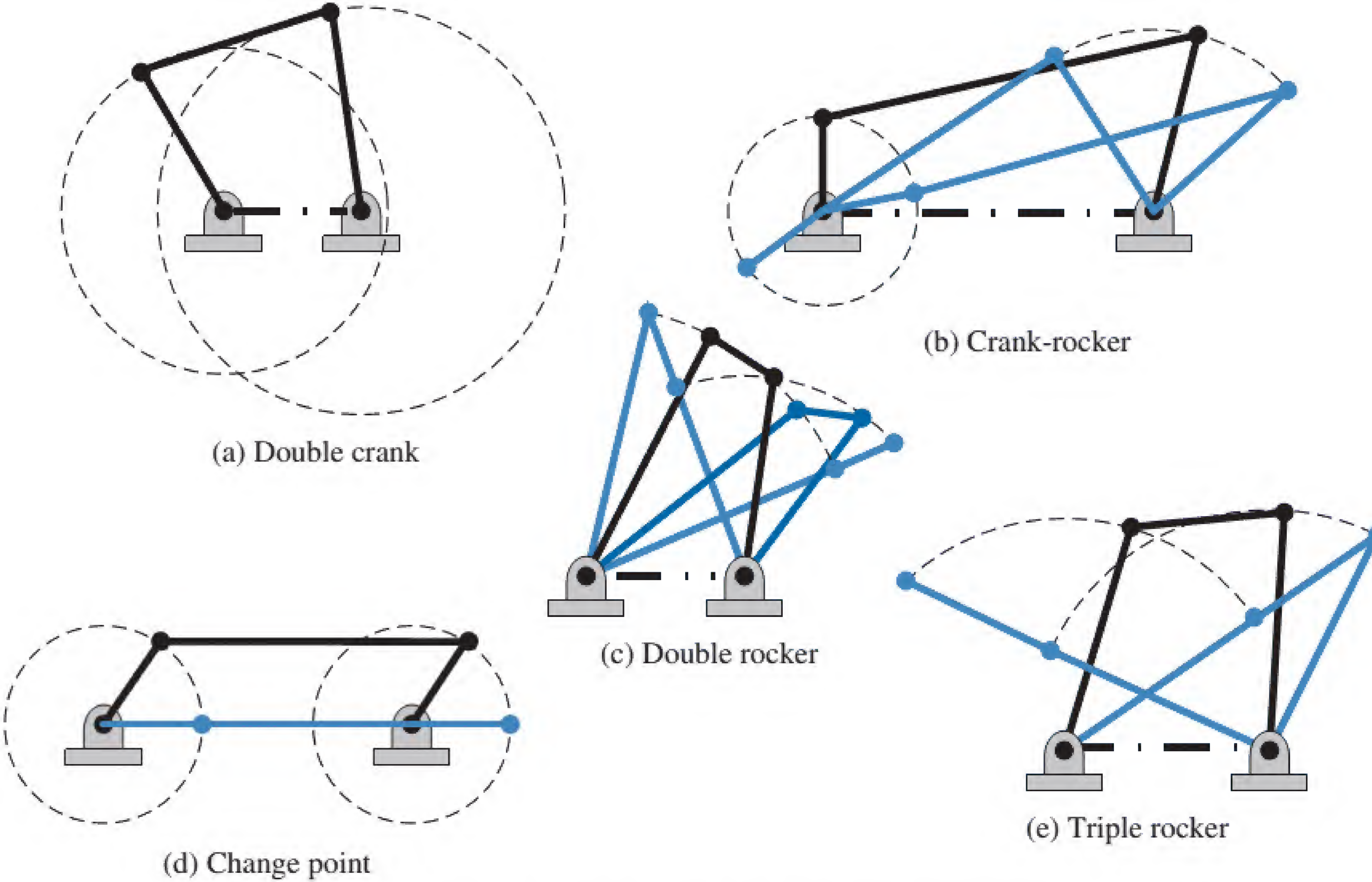


FIGURE 1.34 Categories of four-bar mechanisms.

1.10.2 Double Crank

A double crank, or crank-crank, is shown in Figure 1.34a. As specified in the criteria of Case 1 of Table 1.2, it has the shortest link of the four-bar mechanism configured as the frame. If one of the pivoted links is rotated continuously, the other pivoted link will also rotate continuously. Thus, the two pivoted links, 2 and 4, are both able to rotate through a full revolution. The double crank mechanism is also called a drag link mechanism.

1.10.3 Crank-Rocker

A crank-rocker is shown in Figure 1.34b. As specified in the criteria of Case 2 of Table 1.2, it has the shortest link of the four-bar mechanism configured adjacent to the frame. If this shortest link is continuously rotated, the output link will oscillate between limits. Thus, the shortest link is called the *crank*, and the output link is called the *rocker*. The wiper system in Figure 1.33 is designed to be a crank-rocker. As the motor continuously rotates the input link, the output link oscillates, or "rocks." The wiper arm and blade are firmly attached to the output link, oscillating the wiper across a windshield.

1.10.4 Double Rocker

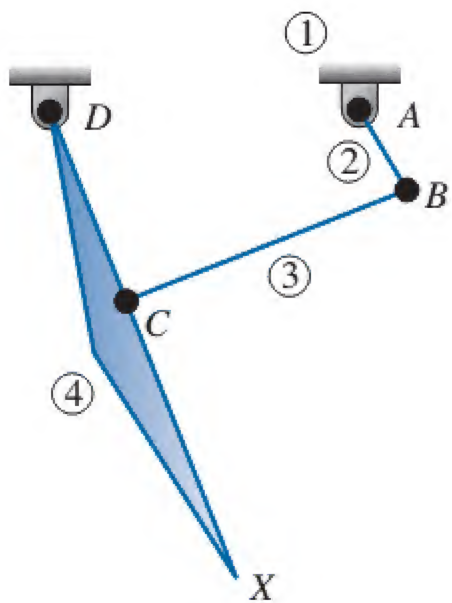
The double rocker, or rocker-rocker, is shown in Figure 1.34c. As specified in the criteria of Case 3 of Table 1.2, it has the link opposite the shortest link of the four-bar mechanism configured as the frame. In this configuration, neither link connected to the frame will be able to complete a full revolution. Thus, both input and output links are constrained to oscillate between limits, and are called rockers. However, the coupler is able to complete a full revolution.

1.10.5 Change Point Mechanism

A change point mechanism is shown in Figure 1.34d. As specified in the criteria of Case 4 of Table 1.2, the sum of two sides is the same as the sum of the other two. Having this equality, the change point mechanism can be positioned such that all the links become collinear. The most familiar type of change point mechanism is a parallelogram linkage. The frame and coupler are the same length, and so are the two pivoting links. Thus, the four links will overlap each other. In that collinear configuration, the motion becomes indeterminate. The motion may remain in a parallelogram arrangement, or cross into an antiparallelogram, or butterfly, arrangement. For this reason, the change point is called a singularity configuration.

1.10.6 Triple Rocker

A triple rocker linkage is shown in Figure 1.34e. Exhibiting the criteria in Case 5 of Table 1.2, the triple rocker has no links that are able to complete a full revolution. Thus, all three moving links rock.



A nosewheel assembly for a small aircraft is shown in Figure 1.35. Classify the motion of this four-bar mechanism based on the configuration of the links.

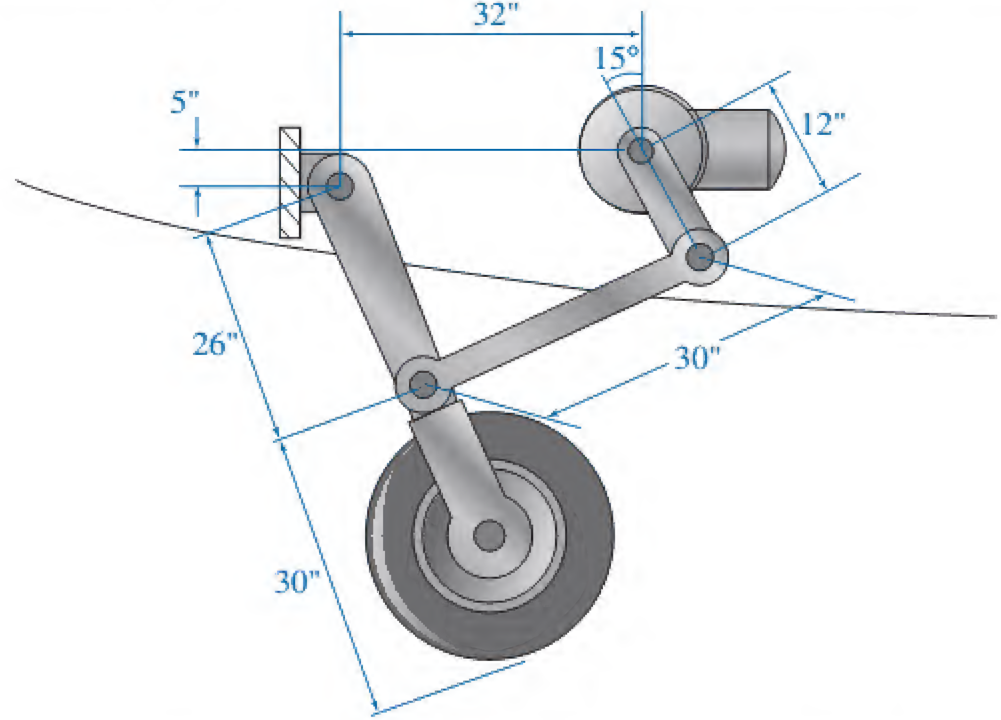


FIGURE 1.35 Nosewheel assembly for Example Problem 1.9.

The lengths of the links are:

$$s = 12 \text{ in.}; \; l = 32 \text{ in.}; \; p = 30 \text{ in.}; \; q = 26 \text{ in.}$$

3. ***Check the Crank-Rocker (Case 2) Criteria***

Is:

$$s + l < p + q$$

$$(12 + 32) < (30 + 26)$$

Because the criteria for a crank-rocker are valid, the nosewheel assembly is a crank-rocker mechanism.

s = length of the shortest link

l = length of the longest link

p = length of one of the intermediate length links

q = length of the other intermediate length links

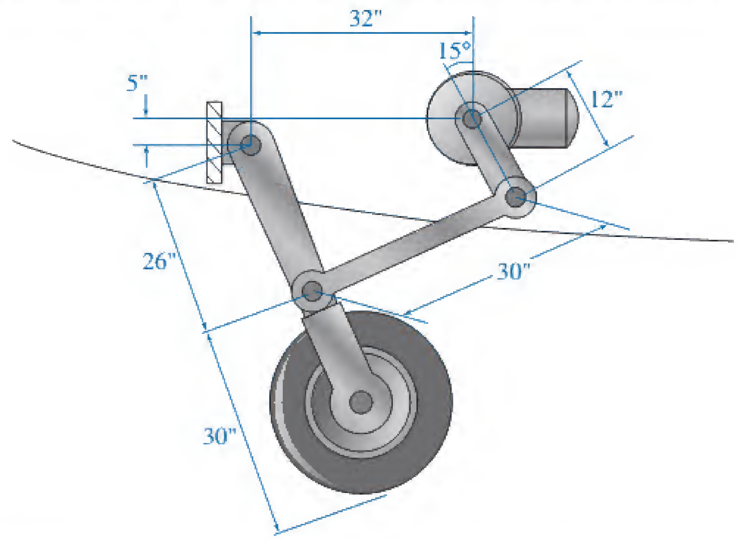
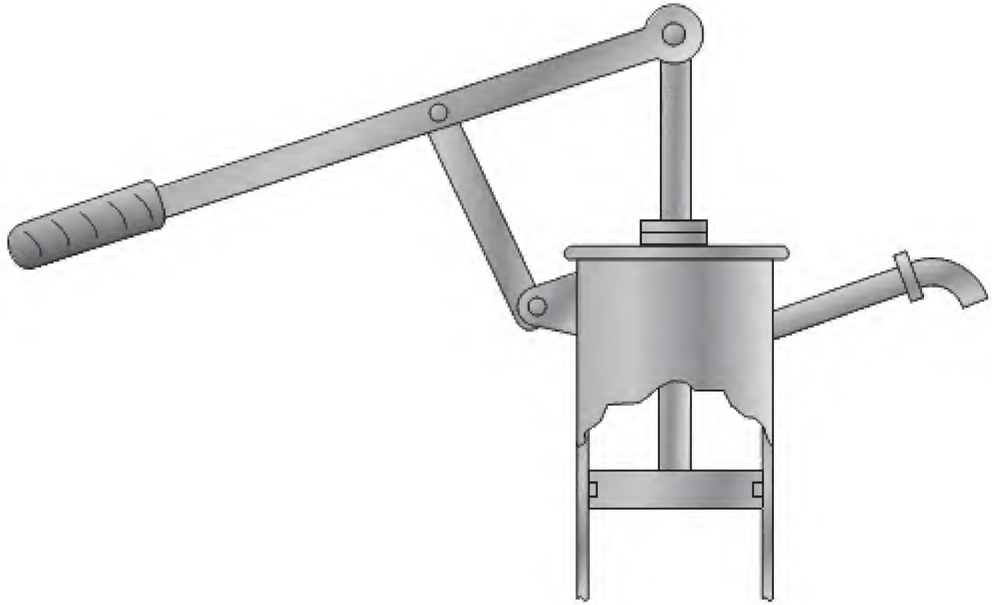
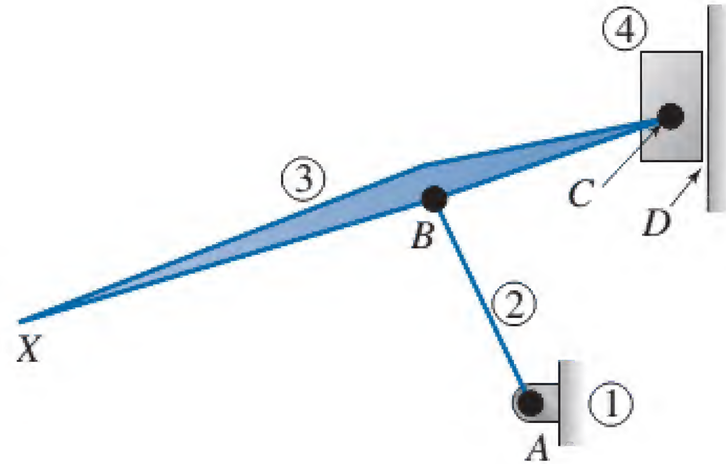


FIGURE 1.35 Nosewheel assembly for Example Problem 1.9.



(a)



The mobility of a slider-crank mechanism is represented by the following:

$$n = 4, j_{\mathrm{p}} = (3 \text{ pins} + 1 \text{ sliding}) = 4, j_{\mathrm{h}} = 0$$

and

$$M = 3(n - 1) - 2j_{\mathrm{p}} - j_{\mathrm{h}} = 3(4 - 1) - 2(4) - 0 = 1.$$